The Chemistry of Extragalactic Globular Clusters

M.Kissler-Patig[1], T.H.Puzia[2], R.Bender[2], P.Goudfrooij[3], M.Hempel[1], C.Maraston[2], T.Richtler[4], R.Saglia[2], and D.Thomas[2]

[1] European Southern Observatory, Germany
[2] Sternwarte der LMU München, Germany
[3] Space Telescope Science Institute, USA
[4] Universidad de Concepción, Chile

Abstract. We present preliminary results of VLT/FORS spectroscopy of globular clusters in nearby early-type galaxies. Our project aims at studying the chemistry and determine the ages of globular cluster (sub-)populations. First results indicate that the different galaxies host from little to significant intermediate-age populations, and that the latter have α-element over iron ratios closer to solar than the old population that show an α-element enhancement similar to the diffuse stellar light.

1 The Project

Our group (P.I.: M.Kissler-Patig) started a campaign to obtain high S/N spectra of representative globular clusters in early-type galaxies. This work will form the bulk of Thomas H. Puzia's PhD thesis and be used in combination with optical/NIR photometry in Maren Hempel's PhD thesis.

So far, we have obtained intermediate-resolution spectra (R∼800) of globular clusters in six early-type galaxies using the FORS2/MXU instrument attached to ESO's VLT. These data are complemented by spectra of the host galaxy's integrated light out to large radii (2-3 R_{eff}). Our sample covers galaxies with various properties: from bright ($M_B < -20.5$ mag) and faint ($M_B > -20.5$ mag) galaxies, located in the field, in groups, and in clusters.

The aim is to study the chemical composition of globular clusters in order to understand the formation and evolution of their host galaxies. In particular, we are investigating age differences within a galaxy, are looking for differences in ages/metallicities between bright/faint and cluster/field galaxies; and are comparing the line indices of the globular clusters with the ones for the corresponding integrated light at comparable radii.

Here, we presents first results for 4 galaxies:

Galaxy	Type	M_B	ρ	(m-M)
NGC 1380	S0	-20.04	1.54	31.23
NGC 2434	E0	-19.48	0.19	31.67
NGC 3115	S0	-19.18	0.09	29.93
NGC 3379	E1	-19.39	0.52	30.12

2 The Balmer lines

The best age indicators in the Lick system remain the Balmer lines. Among these, Hβ is mostly used, but is super-seeded in diagnostic quality by Hγ_A for good data (see Puzia's contribution in these proceedings).

The Balmer line needs to be plotted against an α-element insensitive index (e.g. [MgFe]) otherwise any derived age is a function of the α-enrichment of that particular globular cluster.

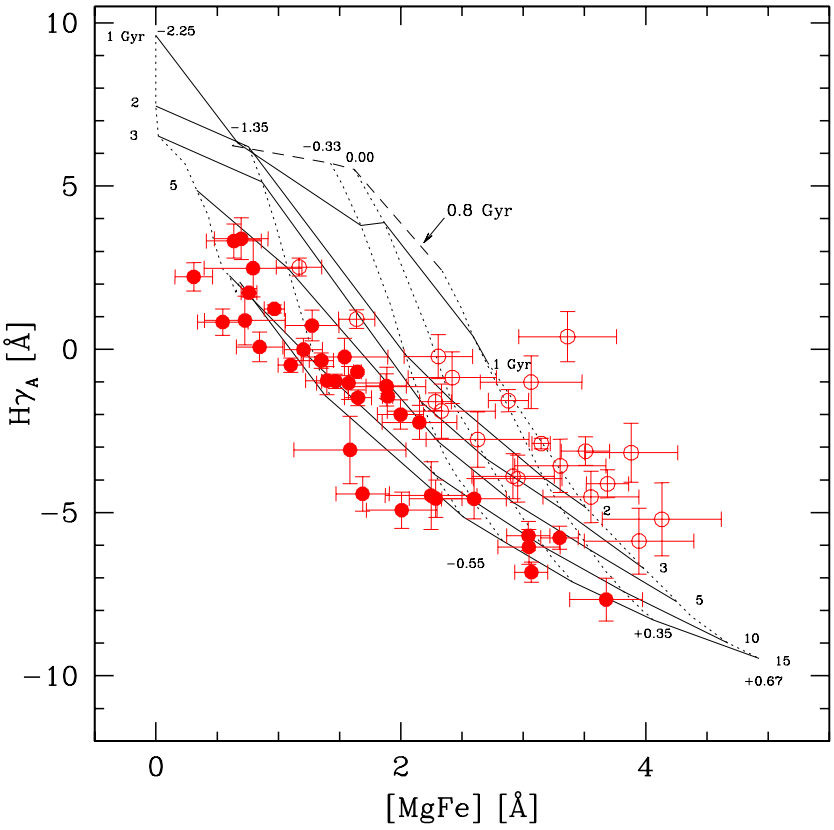

Fig. 1. Hγ_A plotted against [MgFe]

Fig. 1 shows Hγ_A plotted against [MgFe] for all studied globular clusters in the four galaxies. We compare our data to the latest SSP model grid of Maraston et al. (2002) for ages 0.8–15 Gyr and metallicities −2.25 to +0.6 dex. Open symbols represent globular clusters formally younger than 3 Gyr.

3 The Metals

Using the Lick indices, we can probe 1) the total metallicity, best traced by [MgFe], a combination of Mg and two Fe indices that result in a fairly α-element independent quantity; and 2) the α-element ratio, well traced by comparing Fe and Mg.

The total metallicity traces the overall chemical enrichment during the star formation history of the galaxy. As expected from photometric studies, we observe in all galaxies a wide spread in metallicity ranging from [Fe/H]~ -2.5 dex to solar or above.

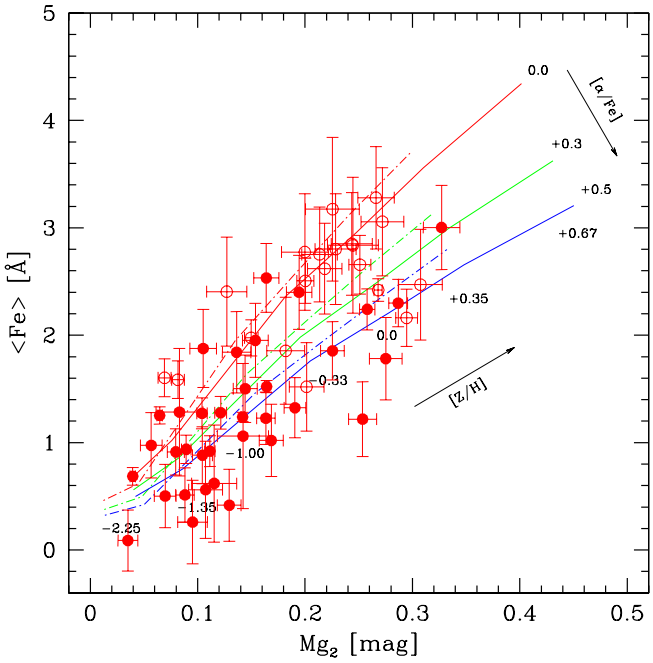

Fig. 2. Mg_2 plotted against <Fe>

Fig. 2 shows Mg_2 plotted against <Fe> as diagnostic for α-element enrichment. The Mg_2 index traces the strength of the Mg (α element) absorption feature at 5180 Å. The <Fe> index is a composite index of two line indices Fe5335 and Fe5270 which trace the strength of strong iron lines at around 5300 Å. The iso-metallicity lines show SSP model predictions computed for three α/Fe ratios (solar, +0.3 dex, +0.5 dex) assuming a 13 Gyr old stellar population (Thomas et al. 2002). The lines range from -2.25 dex (lower left) up to +0.67 dex (upper right) in metallicity. Open symbols show clusters formally younger than 3 Gyr (see Fig. 1).

4 The Results

AGES:

- The most striking feature of the age-metallicity plot is the fact that the globular clusters with metallicities below [Fe/H]~ -0.8 span a very narrow age range around the $\sim$12 Gyr isochrone, i.e. comparable to Milky Way halo clusters. For metallicities above [Fe/H]~ -0.8 dex, the globular clusters show a large spread in ages over several Gyr. In particular, a significant number of intermediate-age clusters appear to be present (the ratio old to intermediate varying from galaxy to galaxy). A caveat to the latter interpretation might be the influence of fluctuations of the horizontal branch morphology. However, the spectroscopic intermediate-ages seem confirmed by optical-NIR photometry (Puzia et al. 2002, Hempel et al. 2002, see also Hempel et al. in these proceedings).

METALLICITY:

- The clusters in all galaxies span a similar metallicity range as in the Milky Way. We found neither super metal-poor nor obvious super metal-rich clusters.
- In all galaxies, the metal-rich clusters ([Fe/H]> -1.00 dex) span a wide range of [α/Fe] ratios indicating a large variety of formation time scales within a single galaxy. Interestingly, the intermediate-age globular clusters appear to have, on average, lower [α/Fe] values than the old clusters. While the bulk of the intermediate-age clusters has ratios close to solar, the old metal-rich clusters tend to be α-element enriched, similar the diffuse stellar light of the host galaxies.

References

1. M.Hempel, M.Hilker, M.Kissler-Patig, T.H.Puzia, P. Goudfrooij & D.Minniti, in preparation (2002), see Hempel et al. in these proceedings
2. C. Maraston, private communication (2002) based on C. Maraston, MNRAS 300, 872 (1998)
3. T.H. Puzia, S.E. Zepf, M. Kissler-Patig, M. Hilker, D. Minniti & P. Goudfrooij, A&A 391, 453 (2002)
4. D.Thomas, C.Maraston & R.Bender, in preparation (2002)